CLAIMS

What is claimed is:

1.   A method for determining a borehole fluid property, comprising:

    generating an acoustic signal within a borehole fluid;

    reflecting the acoustic signal from a known object, wherein the known object converts the acoustic signal into a reverberation signal;

    receiving an acoustic return signal from the fluid, the return signal having a received reflection portion and a received reverberation portion; and

    analyzing the received reverberation portion to determine the borehole fluid property, the analyzing including:

        obtaining a theoretical reverberation portion; and

        relating the received reverberation portion and the theoretical reverberation portion to determine the borehole fluid property.

2.   The method of claim 1 wherein the borehole fluid property is fluid density.

3.   The method of claim 1 wherein the borehole fluid property is fluid impedance.

4.   The method of claim 1 wherein the act of obtaining a theoretical reverberation portion includes:

        convolving the received reflection portion with a theoretical reverberation transfer function.

5.   The method of claim 4 wherein the theoretical reverberation transfer function has a frequency-domain representation $R(w)$ of:

$$R(\omega)=\frac{Z_m-Z_s}{Z_m+Z_s}+\frac{\dfrac{4Z_mZ_s(Z_s-Z_m)}{(Z_m+Z_s)^3}e^{-i2\omega\frac{C_T}{V_s}}}{1-\left(\dfrac{Z_s-Z_m}{Z_m+Z_s}\right)^2 e^{-i2\omega\frac{C_T}{V_s}}}$$

where Z_m is the impedance of the borehole fluid, Z_s is the impedance of the known object, V_s is the speed of sound in the known object, and C_T is the thickness of the known object.

6.   The method of claim 4, wherein the act of relating includes:

calculating a sum of amplitudes of the theoretical reverberation portion;

associating the sum of amplitudes with an impedance used to determine the theoretical transfer function;

repeating said acts of obtaining, calculating, and associating for a different impedance;

fitting a curve to the stored sums of amplitudes;

calculating a sum of amplitudes of the received reverberation portion; and

determining a curve value corresponding to the sum of amplitudes of the received reverberation portion.

7.   The method of claim 4, wherein the act of relating includes:

determining a difference between the received reverberation portion and the theoretical reverberation portion;

comparing the difference to an error tolerance; and

if the difference is greater than the error tolerance,

adjusting the theoretical reverberation transfer function; and

repeating said acts of obtaining, determining, and comparing until the difference is

smaller than the error tolerance.

8.   The method of claim 1, further comprising:

determining an acoustic velocity from a time delay between said generating and

receiving.

9.   The method of claim 1, wherein the known object is a metal object of predetermined

dimensions at a predetermined location.

10.   The method of claim 1, wherein the known object is a disk having a thickness substantially

equal to a half wavelength of the acoustic signal's center frequency.

11.   The method of claim 1 wherein a value for the borehole fluid property at a given location is

obtained in real time.

12.   A tool for measuring one or more fluid properties that comprises:

a body having an associated volume through which a fluid may pass;

a surface fixed within the volume to contact the fluid; and

an acoustic transducer affixed to the body and configured to receive acoustic signal

reflections and reverberations from the surface.

13.   The tool of claim 12, wherein the surface is metallic.

14.   The tool of claim 12, wherein the surface is steel.

15.   The tool of claim 12, wherein the surface has opposite sides configured to contact the fluid.

16.   The tool of claim 15, wherein the surface is a metal disk.

17.   The tool of claim 12, wherein the tool couples to a processor that identifies the acoustic signal reflections, processes the acoustic signal reflections to provide theoretical reverberations, and relates the theoretical reverberations to the received acoustic signal reverberations to determine the one or more fluid properties.

18.   The tool of claim 17, wherein the one or more fluid properties includes acoustic impedance.

19.   The tool of claim 12, wherein the acoustic transducer is further configured to generate acoustic signals that impinge on the surface to cause said acoustic signal reflections and reverberations.

20.   The tool of claim 19, wherein the tool couples to a processor that measures a time delay between the generation of the acoustic signals and the receiving of the acoustic signals to determine an acoustic velocity.

21.   The tool of claim 20, wherein the processor further identifies the acoustic signal reflections, processes the acoustic signal reflections to provide theoretical reverberations, and relates the theoretical reverberations to the received acoustic signal reverberations to determine the one or more fluid properties.

22.   The tool of claim 21, wherein the one or more fluid properties includes fluid density.